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REPORT OF VISITING SCIENTIST ATTACHMENT OF DR. ANTHONY P. PARKER OF UNIVERSITY OF NORTHUMBRIA, U.K. TO BENÉT LABORATORIES JULY - AUGUST 1993

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US ARMY ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
CLOSE COMBAT ARMAMENTS CENTER
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13. ABSTRACT (Maximum 200 words)
The results of a two-month visiting scientist attachment of Dr. Anthony P. Parker from the University of Northumbria at Newcastle, United Kingdom to the U.S. Army Armament Research, Development, and Engineering Center, Benét Laboratories are reported. A description is given of the arrangements for the visit, the technical topics addressed during the visit, and the status of the technical reports that give details of the results of the visit.

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INTRODUCTION

The arrangements for a visit to Benét Laboratories by Dr. Parker were initiated following his inquiry regarding a possible visiting scientist attachment. Dr. Parker is familiar with armament research, having worked with the Royal Armament Research and Development Establishment in the U.K. and as a visiting scientist at the (current) U.S. Army Research Laboratory in Watertown in 1980. Dr. Parker has also lectured at Benét Laboratories and has collaborated with Benét scientists in the area of fatigue of armament materials and structures (ref 1).

Administrative arrangements for the visit were provided by Dr. Roy E. Reichenbach, Chief, Aeronautics and Mechanics Branch, European Research Office, London. Funding of $7.5K to cover part of Dr. Parker's travel expenses was provided by a PM-ABRAMS FY93 program titled "Cracking of Eroded Cannon." This topic, that of the analysis of fatigue cracking in a cannon experiencing erosion, was established as the primary technical topic for the visit. Results for this and other topics addressed during the visit of Dr. Parker are described in the following paragraphs.

TECHNICAL TOPICS

Cracking of Eroded Cannon

The use of increased performance rounds in tank cannon has led to more frequent occurrence of severe localized erosion on the inner diameter of a cannon near the breech end. This type of problem has occurred in U.K. as well as in U.S. cannons. The erosion often occurs as a localized groove that can be the cause of premature cracking in a cannon. The analysis of cracking from localized erosion in a cannon tube was the primary topic of the technical visit of Dr. Parker. Two figures from the paper describing the work (ref 2), give a summary of the results. Figure 1 shows a typical location and configuration of the axially oriented erosion grooves in a 120-mm inner diameter cannon tube. The grooves form just ahead of the chamber, where the outer-to-inner diameter ratio, W, is 2.25. Analysis of the tube, groove, and crack configuration using fracture mechanics resulted in calculations of fatigue life for various values of W and of k_t, stress concentration factor, of the erosion groove, as shown in Figure 2. Note that measured lives from earlier Benét tests of full-size sections of 120-mm cannons are in good agreement with the calculated lives. The good agreement is significant, because it shows that calculated fatigue lives such as those plotted in Figure 2 can be used in conjunction with fatigue life tests to make more accurate determinations of safe fatigue lives of cannons.

Analysis of Bore Evacuators

Holes through the wall of a cannon are often used to evacuate the residual combustion gases after firing of a cannon. Analysis of the fatigue life associated with evacuator holes was a second topic of the visit, as described in References 3 and 4. A typical evacuator hole configuration and fatigue life results are shown in Figures 3 and 4, respectively. The 30-degree orientation of the evacuator hole relative to the cannon tube axis, shown in Figure 3, is commonly used in cannons in the U.K. and in the U.S. Results of fatigue life analysis for various positions along the hole and for various values of tube overstrain and tube material yield strength are shown in Figure 4. The most interesting aspects of the life calculations are the significant effects of overstrain and material strength that occur in a quite narrow range of position along the hole. For positions near the tube inner diameter the fatigue life can be increased tenfold for a tube overstrain of 50 percent, whereas in locations away from the tube inner diameter the tube overstrain and material strength have little effect on fatigue life. This type of life calculation, again in combination with fatigue life tests, will be very useful in safe life determination and design of cannons with evacuators or other types of holes.

Axial Bending of Autofrettaged Tube

Another topic considered during the visit was analysis of the axial bending of a section cut out of an autofrettaged tube. The hoop direction bending of a autofrettaged tube section has proven to be a very useful measure of the autofrettage residual stress in a tube, providing important information for safe life calculations for cannon tubes. The analysis of axial bending may lead to a residual stress measurement method of equal importance for cannons. This analysis is being continued by Dr. Parker and will be compared with instrumented bending tests of tube sections at Benét.

Fatigue of Perforated-Tube Muzzle Brake

Dr. Parker worked with Applied Mathematics and Mechanics Branch scientists during the visit to improve the finite element stress analysis model of a perforated-tube muzzle brake used on advanced cannons. He showed that by using the classic and powerful method of superposition, the size and accuracy of the muzzle brake model could be significantly increased with little increase in computation time. This will allow more complete and realistic modeling of this new type of perforated-tube muzzle brake.

SUMMARY

1. The visiting scientist attachment of Dr. Parker to Benét Laboratories was arranged through Dr. Reichenbach of the European Research Office in London and was funded through a PM-ABRAMS program.

2. The primary technical topic--*Cracking of Eroded Cannon*--was completed and published as an ARDEC technical report and submitted as an ASME paper (ref 2).

3. A secondary topic--*Analysis of Bore Evacuators*--was completed and published as an ARDEC technical report and will be submitted as an ASME paper (ref 3). Additional work on this topic is continuing and has been submitted as an ARDEC technical report (ref 4).

4. Two additional topics--*Axial Bending of Autofrettaged Tube* and *Fatigue of Perforated-Tube Muzzle Brake*--were addressed during the visit. Additional work on these topics is planned.

RECOMMENDATION

Benét Laboratories should consider establishing a policy on scientific exchanges that: (1) encourages 2 to 12 month exchanges to and from the U.K. and Australia; and (2) sets standards for salary, expenses, technical support, and entry and mail arrangements.

The only problems associated with the visit of Dr. Parker to Benét involved the last item mentioned above, entry and mail arrangements. The experience gained from this visit can be used to make better arrangements for future visiting scientist attachments at Benét Laboratories.

REFERENCES

1. A.P. Parker, J.H. Underwood, J.F. Throop, and C.P. Andrasic, "Stress Intensity and Fatigue Crack Growth in a Pressurized, Autofrettaged Thick Cylinder," *Fracture Mechanics: Fourteenth Symposium - Volume I: Theory and Analysis, ASTM STP 791,* J. C. Lewis and G. Sines, Eds., American Society for Testing and Materials, Philadelphia, 1983, pp. 216-237.

2. J.H. Underwood and A.P. Parker, "Fatigue Life Analyses and Tests for Thick-Walled Cylinders Including Effects of Overstrain and Axial Grooves," U.S. Army ARDEC Technical Report ARCCB-TR-94038, Benét Laboratories, Watervliet, NY, September 1994; also submitted to *ASME Journal of Pressure Vessel Technology.*

3. A.P. Parker and J.H. Underwood, "Stress Concentration, Stress Intensity, and Fatigue Crack Growth Along Evacuators of Pressurized, Autofrettaged Tubes," U.S. Army ARDEC Technical Report ARCCB-TR-94046, Benét Laboratories, Watervliet, NY, December 1994; also to be submitted to *ASME Journal of Pressure Vessel Technology.*

4. J.H. Underwood, A.P. Parker, D.J. Corrigan and M.J. Audino, "Fatigue Life Measurements and Analysis for Overstrained Tubes with Evacuator Holes," U.S. Army ARDEC Technical Report to be published.

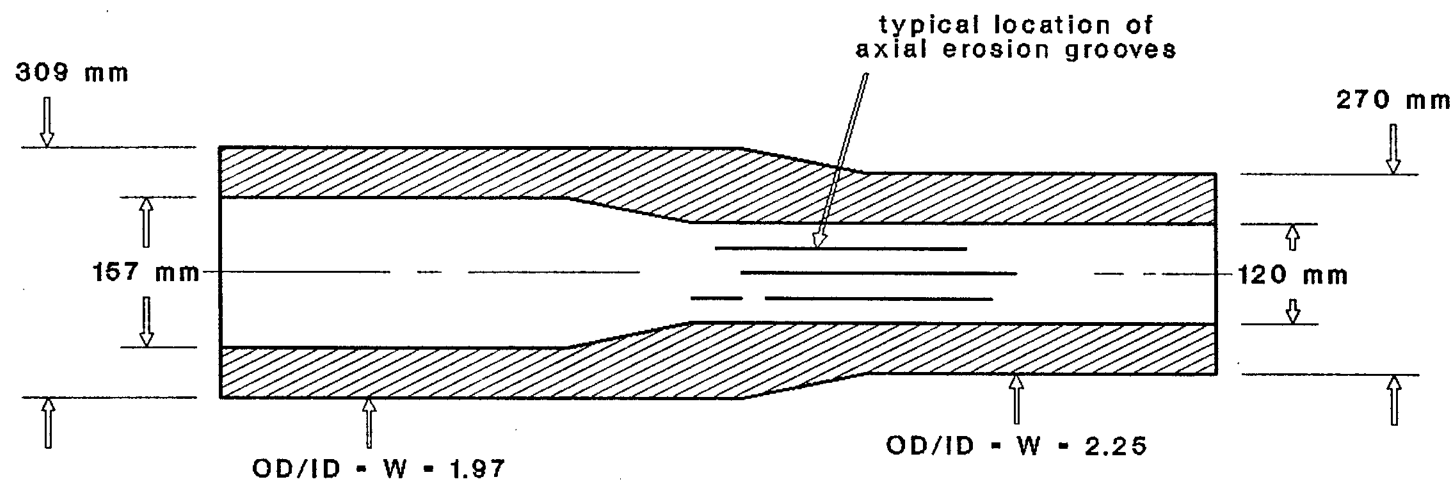

FIG. 1 - Configuration of Eroded Cannon

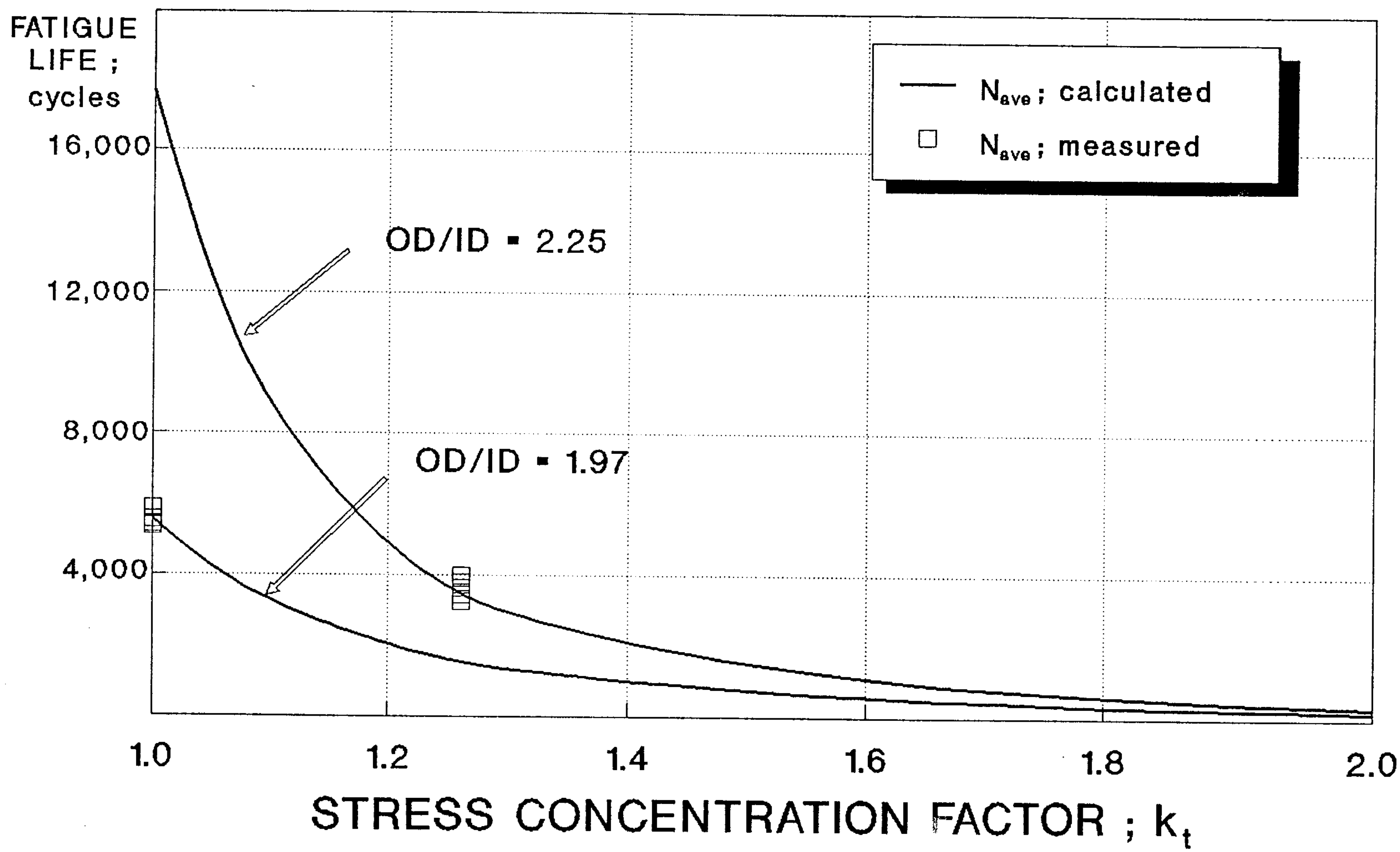

FIG. 2 - Effect of Stress Concentration Factor on Fatigue Life of Eroded Cannon

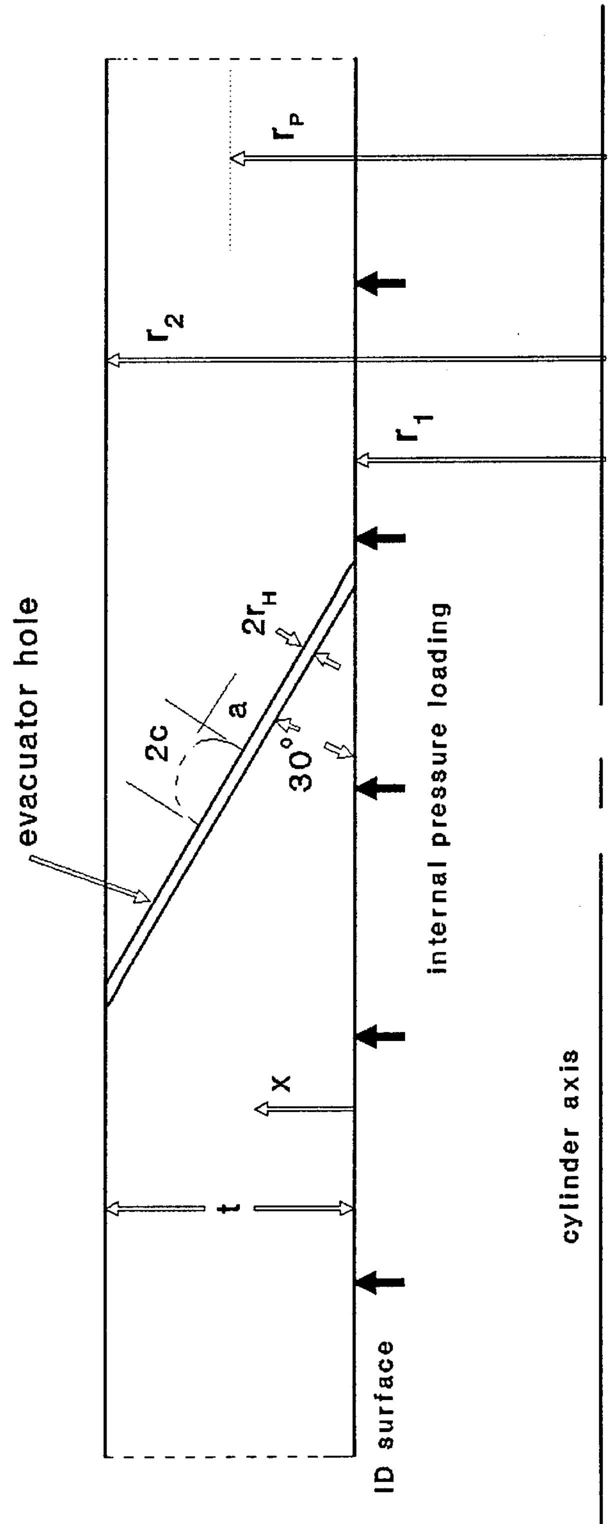

FIG. 3 - Bore Evacuator Configuration

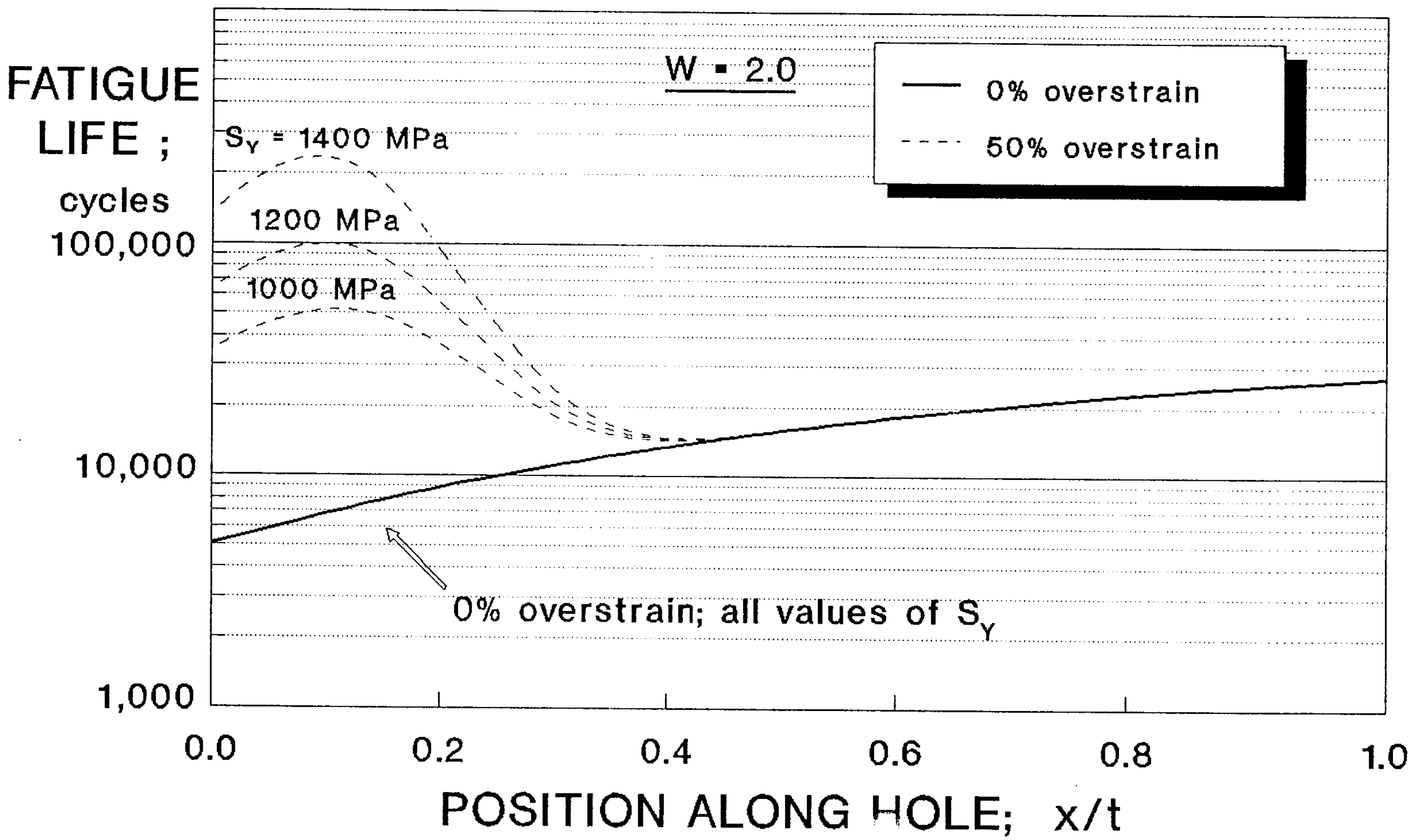

FIG. 4 - Fatigue Life for Evacuator in Tubes with 0% and 50% Overstrain and Various Material Yield Strengths

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